

SCIENCE

NEW YORK, OCTOBER 9, 1891.

BURIAL CUSTOMS OF THE HURONS.¹

THE region to which I desire to carry my audience is one full of historic interest, made doubly so from the fact that Parkman has so frequently referred to this part of North America in his valuable writings, and also from the fact that the early Jesuits first commenced their missionary labors in this district. No matter how one may view or in what light one may regard the work which the Jesuits had undertaken in Christianizing the aborigines, we cannot but admire their great zeal, endurance, and indomitable courage; and students in quest of knowledge concerning the traits of the Indians are deeply indebted to these missionaries for their keen observations and copious notes, which gave us such an insight into the aboriginal manners and customs. The Huron Indians inhabited what is now known as the County of Simcoe, in the Province of Ontario, Canada, situated between two large bodies of water: on the north lies the Georgian Bay, with its 30,000 islands, and on the south the clear crystal waters of Lake Simcoe. The locality was in every way an ideal one for an aboriginal site. The country was well wooded, game was plentiful, large and small lakes abounded, which not only gave a plentiful supply of pure water, but were also full of fish, while small streams flowed in various directions. With such favorable surroundings it is not surprising that the Hurons had remained in the same locality for centuries, and had it not been for their implacable foes, the Iroquois, they might possibly be there yet. But in 1649 their dreaded enemy descended upon them and slaughtered Indian and Jesuit alike, and the few who escaped sought refuge in the islands of Georgian Bay, from whence shortly afterwards they removed to Lorette, near Quebec, where the remnants of that once great tribe can be now found and are known by the name of Wyandots. The County of Simcoe has proved a most prolific field for the archaeologist to work in, and for fifteen years I have devoted much time to the examination of earthworks and to the collecting of relics. I have secured some four thousand objects in stone, shell, bone, pottery, and copper. Many of the specimens deserve to be ranked amongst the finest of the so-called Neolithic period. As reports of the various forts and earthworks which I have surveyed have appeared frequently in public print, I shall not now refer to them; I desire simply to make a few remarks on the burial customs of the Hurons.

Their places of sepulture are of three kinds, — the ossuaries (or depositories of human bones), single graves, and mounds. The ossuaries contain the remains of from a few to several thousand bodies, and it is principally in these that specimens are found. I might say that I opened one of these large pits in South Orillia township and dug through human bones nearly ten feet deep. In order to account for the interment in such large numbers in one spot, it is necessary to explain the custom which resulted in such a practice.

¹ Notes of a paper read before the American Association for the Advancement of Science, at Washington, by Charles A. Hirschfelder, U. S. Vice Consul, Toronto, Canada.

The "Feast of the Dead" was one of the Indians' most solemn and religious rites; when an Indian died, it was the custom from time to time to erect a rough stage, place the body on top, and every eight or ten years collect the remains so placed, scrape the flesh from the recent dead, and bury them in one large hole. The functionaries on whom the duty of scraping devolved were denominated "bone-pickers." As the bodies were cast in promiscuously, it is very difficult to find perfect crania among the bones so deposited. From thirty of these ossuaries I have only succeeded in securing about forty perfect ones. One skull was particularly interesting from the fact that it had been broken through in three separate places, and yet the Indian had lived for years, apparently, as the wounds were completely healed. When one has seen an ossuary it is easy to recognize them whenever one may find them, owing to the circular depression of the surface, which is traceable to the decay of the bones. One singular circumstance in connection with these ossuaries is worthy of mention, and it is that they either contain many relics or are entirely devoid of them.

With regard to the single graves, of which I have opened some 350, I do not suppose there were more than fifty which contained anything but human bones. In certain cases the bodies were in a sitting posture, but usually they were not placed in any particular position. The sepulchral mounds in the United States are usually very large, but the Huron mounds are only three to four feet high and about sixty feet in circumference, and of no regular shape. These contain from six to twelve bodies, placed some two feet apart; differences in the shape of the crania are observable in many of these sepulchral places. This might be accounted for by the practice of attaching prisoners of war to the several tribes, and also by that of occasionally uniting the remains of a shattered tribe with a tribe that had conquered. There is certainly a difference in crania which have been found in the same locality, so that if we were to find the brachycephalic and the dolichocephalic types under the same mound we should in this way be able to account for such an occurrence. Besides, intermarriage among members of the same clan was forbidden by some tribes, so that if a member of the Turtle Clan aspired to the paternity of a Romulus or Remus it behooved him to seek the affections of a lady from some other clan than his own. In a pamphlet sent me by its author, Mr. Lucien Carr of the Peabody Museum, Boston, Mr. Carr gives the mean measurement of sixty-seven crania taken from stone graves in Tennessee: he found five dolichocephalic, eighteen orthocephalic, twenty-nine brachycephalic, and fifteen much flattened. Mr. Carr observes that the measurement of the above mentioned crania (exclusively of the flattened heads) indicates that they belong to the two extremes of classification. The measurements of Mr. Carr correspond with my own experience, for I have observed a considerable diversity in the crania of the ossuaries, mounds, and single graves. The dolichocephalic type is characteristic of the eastern tribes. Crania which have undergone compression when young have a conformation which is as manifest internally as it is by the exterior. It is by many believed that the burial of articles with the dead was a religious act, but

my own observations do not lead me to think that it was necessarily so. We know that the Indians lived strictly up to their belief, and if it had been an act of religion to thus bury articles, I maintain that in each and every grave some articles would be found. But, as I have pointed out, the single graves do not, in many cases, contain anything; and where the large ossuaries have been carefully examined, some of them have not contained a pipe or bead, while a single ossuary in close proximity might contain a thousand articles. Now, my theory is this, if one of these "feasts of the dead" should occur during a propitious season, many articles could be spared, but if a famine stared the Indians in the face, which frequently happened, they would be too poor to spare articles, and it appears to me that the act of burial was not one of religion but an act of respect.

The valuable paper by Mr. Wilson on jade articles, and the theory advanced by Professor Putnam that possibly the jade for making these objects came from China, is one worthy of close investigation, but must at present be referred to with much caution. That the aborigines traded over a vast extent of country is evidenced by the fact that we find southern shells, *pyrula perversa* and other such species, in our most northern graves, while in the South copper implements are found which show by their laminated structure that they are of aboriginal workmanship, and the material is identified as coming from Lake Superior from the large amount of silver it contains.

SPONGE TRADE OF THE BAHAMAS.

A RECENT report by United States Consul McLain of Nassau contains much interesting information about the sponge trade of the Bahama Islands. The vessels used in the sponge trade in those islands are small craft, varying in size from five to twenty-five tons burden, and are either schooner or sloop rigged. They are all built in local shipyards, and their construction and repairs constitute an important business in itself. The frames are generally made of Madeira wood, a hard, tough wood of native growth, the planking and other material being of yellow pine imported from the Southern States. Each vessel carries two or three small open row or scull boats, with a crew of from eight to twelve men. These vessels have an average life of from sixteen to twenty years, undergoing, of course, occasional repairs. It is thought that there are from four hundred and fifty to five hundred of these vessels.

The number of persons engaged in the business of gathering sponges in the Bahamas, handling them, and preparing them in various stages for market, is from five to six thousand, all of whom, except the shipowners, brokers, and shippers, are colored people. Hands employed in clipping, washing, packing, and preparing finally for shipment abroad, get from fifty to seventy five cents per day of ten hours. The amount earned by the men who go fishing for sponges cannot be given, as their pay depends entirely on the number of sponges obtained. The owner of the vessel fits her out at his own expense, and the profits of the voyage are divided up in shares among the owner, the master, and the men. They are never hired by the month, nor do they ever get specified wages. The most that can be said is that the men make a tolerable living, and the sponge fisherman who earns over three hundred dollars a year is the exception. The owners of the vessels, as a rule, have their own shops, from which the vessels are fitted out, and on supplies thus furnished the owner makes a profit in addition to others. The shipowners, generally speaking, find considerable profit in the business, whilst the fishermen, if not able to lay up any money from the pursuit, are yet enabled to rely upon it for a moderate living.

The method of gathering sponges is by means of iron hooks attached to long poles. By using a water-glass the fisherman can readily discover the sponges at the bottom, and then with his pole and hook he will bring up those he may select as fit for his purpose, leaving the smaller ones untouched. Some sponges adhere

firmly to the bed of the sea, while others are not attached at all, these latter being known as "rollers." About ten years ago an attempt was made to introduce dredges; but it was found that their use was likely to ruin the beds, because in passing over the bottom they dislodged and brought up not only the good sponges, but the young and unsalable ones as well, killing the spawn and working great mischief. The ordinary fishermen also made an outcry, declaring that the use of dredges interfered with their rights. An act was passed by the legislature forbidding the use of dredges, and only the pole and hook are now used.

When the sponge-field is reached the vessel anchors, and the men, putting off in the small open boats, do the fishing in the manner above indicated, returning to the vessel before nightfall with their catch. The sponges, when brought to the vessel, are at once spread upon the deck, and are left exposed to the sun for several days, during which time the animal matter that covers the sponge gradually dies. This is a black, gelatinous substance of a very low order of marine life, which during the process of decay emits a most objectionable odor. The vessels visit what is called the "kraal" once a week to land the load from the deck. The kraal is an inclosed pen, fenced in by sticks of wood so as to allow a free circulation of water through it, usually built in a sheltered and shallow bay or cove, on one of the cays near by. The sponges are placed in the kraal and left to be soaked and washed by the action of the water from four to six days, when they are taken out and beaten with sticks until the decayed covering is entirely removed. Having been subjected to this course of exposure, soaking, beating, and washing, the sponges are quite clean, and are taken on board the vessel, packed away in the hold, conveyed to Nassau, and in this condition are sold in the local market.

The average catch per trip cannot be stated, as the cargoes vary greatly in size and value. Of the larger sponges a catch of five thousand, or of the smaller ones seven thousand five hundred, would be considered a fair lot. Occasionally a cargo of from twelve to fifteen thousand large sponges has been brought in, but this success is exceptional. The vessels are provisioned and fitted out, as a rule, for a voyage of about six weeks, and generally from seven to eight voyages are made per annum.

There cannot be said to be any season for sponge-gathering, as it goes on all through the year. A number of vessels are often laid up, however, during August and September, the men being timid and afraid of hurricanes during that period. Of course the quieter the weather and smoother the sea, the better the chances are for making a good catch, as nearly all the work is done in small open boats from ten to twelve feet in length. Much also depends upon the energy and the industry of the crew, and there is luck in finding a locality where the sponges are valuable and abundant.

As to the length of time required for sponges to grow to good marketable size little definite can be said; none of the fishermen are able to tell, though many volunteer opinions that differ widely. It is a matter to be determined by future scientific investigation, but it is believed it will be found that a healthy sponge will reach a marketable size in from twelve to eighteen months under ordinary conditions of growth. No attempts have been made, worthy of mention, to cultivate the sponge in these waters.

The sponges are prepared for export in the following manner. After being bought in the local market they are carted to the shipping yard of the purchaser, where they are cut and trimmed into proper shapes and sizes; they are then washed and thoroughly dried, being generally spread in the sun for that purpose upon canvas or old sails; next they are assorted according to varieties and grades, and then packed by means of hand presses into bales weighing from twenty to a hundred and fifty pounds. Sometimes the sponges are bleached by being passed through a solution of white lime and water, so weak as not to injure the fibre of the sponge. The consul does not know of any process resorted to for coloring the sponges, and few, indeed, are even bleached at present.

When offered for sale in the local market, the sponges are either piled up loose or made into strands or beads of from two to ten sponges each. The best sponges are usually made into strings of from eight to ten sponges each, the price averaging about sixty

cents per string. Others are generally sold in lots not strung. The buyer, however, is not guided in his purchase by the number of sponges on a string, but by what a certain lot will weigh, and the weight is never given, but the buyer must estimate it. Hence practical experience is needed in the purchasing of the sponges.

Sponges are offered for sale on five days of the week at the sponge exchange. They are landed from the vessels, and each cargo is piled up by itself. The weight is entirely unknown. The buyers examine the lots, and each man hands in a private tender, in writing, for the lot, and it is awarded, on opening the tenders, to the highest bidder. A successful buyer must be able to judge correctly by his eye and experience just how many pounds of good sponges he will be able to get out of a given lot when it has been carefully worked up. Nearly all the sponges are bought by resident agents, who buy for New York, London, and Paris houses, shipping the goods to their principals. A few merchants handle sponges on their own account.

Along the southern coast of Florida the sponge business is in a flourishing condition, and has been for years, with its headquarters at Key West, and hundreds of the people of that vicinity are engaged all the time in gathering, curing, and shipping sponges. Many natives of the Bahamas visit Florida from time to time and find employment in the sponge business; though all the crews necessary to introduce the business on the Gulf coast of Florida, men well versed in the industry, can be obtained easily at Key West, without the least necessity of importing labor into the State from the Bahamas. It is said that the sponges growing along the Florida coast are much superior to the sponges of the Bahamas.

THE KHEVSURS OF THE CAUCASUS.

MONSIEUR V. DINGELSTEDT has published some notes on this singular people in *Le Globe* (tome xxx. No. 2), an abstract of which appears in the *Scottish Geographical Magazine* for September. The name is derived from the Georgian word *Khêvi*, signifying a mountain gorge, and is unknown among the people to whom it is applied. They call themselves after the different localities they inhabit not by any collective name. Their country is situated to the east of the Pass of the Cross, on both slopes of the central chain of the Caucasus, to the west and north-west of the mountain Bôrbalo, and has an area of about 570 square miles. Its mean altitude is over 6,500 feet, and it contains peaks rising above the limit of eternal snow, which, in the central part of the Caucasus, is at an elevation of 10,600 feet. About seven thousand persons inhabit this wild region, in a bleak climate, where the cultivable soil is of small extent and the vegetation poor.

In the summer the Khevsurs feed cattle and sheep on the rich grass which springs up on the mountain slopes, but in the winter forage is difficult to obtain, and the animals and their owners often succumb to famine. The Khevsurs, in contrast to the other mountaineers of the Caucasus, are plain in appearance, of rather short stature, and with large hands and feet, though they are muscular and agile. A great variety is observable in the color of their eyes and hair, their stature, and even in the form of their skulls, and this diversity may be ascribed to a mixture of race. Their original ancestors were probably Georgians, who, some time before the twelfth century, took refuge in the mountains. These were probably joined by men of other races, who, for various reasons were obliged to fly from their native lands, or were attracted by the life of brigandage which the Khevsurs led up to recent times. Their Georgian ancestors had reached a fairly high standard of civilization, but in their savage solitudes the Khevsurs have relapsed into semi-barbarism, and have now a fierce and defiant expression. They wear coats of mail, brassards, and helmets, like cavaliers of the Middle Ages. They live in communities consisting of one or several villages, under the nominal authority of a chief called a *Khevisberi*. These villages are grouped around some spot supposed to be sacred to a saint, and this religious bond has taken the place of the old tribal unity.

The Khevsurs have a vague belief in one God, but they never address him in prayer, and their rites consist in sacrifices and invocations to various saints, Christian and pagan, among which Saint George is held in high repute. Most of the work falls on

the women, while the men spend their time in idleness. Marriages are concluded either with Christian or pagan rites. The wife brings with her a dowry of cattle and a trousseau. The offspring of the cattle belong to the house of the husband, but the original herd is the private property of the wife, and any loss must be made good by the husband. The wife has no share in the property of her husband at his decease. It is divided among his male heirs, and, in default of these, goes to the community. So, too, the wife's property is divided among her sons, her trousseau only being left to her daughters.

Monogamy is the rule, but custom permits a man to repudiate his wife when she grows old, or if she bears no children, and to take another, provided that he gives an indemnity of five or six cows to the parents of the former. In other cases divorce is easily effected, but is seldom resorted to. The dead are buried in vast caves. They are dressed in coats of mail, and sometimes musical instruments are placed in their hands. Festivals are held in their honor five times, or, in the case of poor families, twice a year, when there is a lavish display of hospitality, and quarrels frequently take place.

NOTES AND NEWS.

In the last paragraph on page 192 of *Science* for Oct. 2, "An initial velocity of seven miles a second," should read, "An initial velocity of six miles a second."

— Amos E. Woodward, late assistant geologist on the Geological Survey of Missouri, died of pneumonia at Castle, Mont., in the last week of September. During his connection with the Missouri survey, Mr. Woodward's special subject was the mineral waters of the State, though he also conducted much other work in the laboratory. He was a painstaking, ambitious, and most industrious worker, and was held in high esteem by those who knew him.

— The flesh-colored, hydrated manganese sulphide which is obtained by the addition of ammonium sulphide to a solution of manganize chloride, on standing, or more rapidly on boiling with water, changes color to green. This green sulphide when washed and dried yields a powder of the same color, which is also unstable, being oxidized by mere exposure to air. It is, however, according to P. de Clermont and H. Guiot (*Mining and Engineering Journ.*), rendered permanent by removing its water of hydration, which is effected by heating it moderately in a current of hydrogen sulphide, carbon dioxide, or ammonia. Thus prepared it is suitable for application in paper staining, etc.

— Dr. L. Webster Fox is of opinion, says *Nature*, that savage races possess the perception of color to a greater degree than do civilized races. In a lecture lately delivered before the Franklin Institute, Philadelphia, he stated that he had just concluded an examination of 250 Indian children, of whom 100 were boys. Had he selected 100 white boys from various parts of the United States, he would have found at least five of them color-blind: among the Indian boys he did not discover a single case of color-blindness. Some years ago he examined 250 Indian boys, and found two color-blind, a very low percentage when compared with the whites. Among the Indian girls he did not find any. Considering that only two females in every 1,000 among whites are color-blind, he does not think it surprising that he did not find any examples among the Indian girls.

— Some time ago the Field Naturalists' Club of Victoria organized an excursion to the Kent group of islands, the object being to collect specimens, and to determine whether the group is most nearly related with Victoria, to which it is closest geographically, or with Tasmania. At the annual *conversazione* of the club, held recently, as we learn from *Nature*, Mr. C. A. Topp, the retiring president, referred to the results of the expedition. The bulk of the fauna and flora were found to be common to Victoria and Tasmania, but there were six or seven varieties of birds peculiar to Tasmania to two peculiar to Victoria. The conclusion was that the islands had been separated from Tasmania after that island was disjoined from the mainland. Among the plants, several

forms were found varying somewhat from the typical forms of the same species on the mainland; while it was interesting to find that the arboreal short-eared opossum had changed his habits so far as to feed on the leaves of the eucalypt, and to keep to the ground.

— M. de Groot of the Dutch Colonial Government in the East Indies has made an interesting communication to the Geographical Society of Amsterdam on the subject of Chinese emigration, which is briefly quoted in the Proceedings of the Royal Geographical Society for September. According to the writer, the causes of this emigration are not to be found in the excess of population, but simply in the poverty of the soil of the provinces whence these emigrants come. It is the bare, mountainous valleys of the eastern part of China which furnish the emigrants to the English, Spanish, and Dutch colonies; to California, Australia, and especially to Indo-China and Cochin-China. The prevailing formation of the ground in their native regions is granitic; the soil yields hardly anything, and the rainfall is slight. Potatoes and vegetables of very bad quality are the only food that can be extracted from the earth. In some favored spots a little rice, but of a poor description, can be grown. Another cause of the emigration is disafforestation. Wood is very scarce, and consequently very dear. Vegetation being almost entirely plucked up, the formation of a new layer of humus is absolutely impossible. The population of these regions is therefore compelled to seek subsistence in other countries. The writer is of opinion that as soon as China sets herself in earnest to construct a network of railways and to carry out other great works, the stream of emigration, which is causing so much anxiety in many parts of the world, will be stopped, as the people will find in the interior of their own country the work and means of livelihood which they now seek for elsewhere.

— The Illinois experiment station is located at Champaign, on a black prairie soil, upon which fertilizers, except barn-yard manure, have failed to produce any increase in wheat. The following experiments, made on soils of a different character, are reported by Professor Morrow in a recent bulletin of the station: For three years past experiments with commercial fertilizers on wheat have been tried at points farther south than the station grounds. For 1890-91 the trials were made on the farms of W. W. Bowler, Flora; A. M. Woodward & Co., Odin; Chas. Stephani, Nashville; and Fred. Helms, Wilderman, near Belleville. These are all not far from latitude $38^{\circ} 30'$, and, except the last-named, on the level light-colored soils characteristic of that region. Mr. Helms's soil is darker colored and naturally very fertile. Mr. Bowler's land had been in grass from 1883 to 1888. In 1889 it produced about forty bushels of corn per acre. In 1890 it was sown to oats, but the crop failed. The land at Odin had been thrown out of cultivation until 1889, when it produced a fair crop of corn. In 1890 it was sown to oats, which failed to produce a crop. The land at Nashville had been in cultivation about forty years—in corn in 1883 and 1884, oats in 1885, wheat in 1886, oats in 1887, wheat in 1888 and 1889, and in oats in 1890. Mr. Helms's land had been cultivated by him twenty-two years without manure. It was in wheat on clover sod in 1889-90, and yielded about thirty bushels per acre. In each case, except at Flora, nine plats two by twenty rods, containing one-fourth of an acre each, were used. To plat 1 in each case five wagon-loads of barnyard manure were applied, and 100 pounds of glue-factory superphosphate to plats 3, 4, 6, 7, and 9. The barnyard manure and superphosphate were applied before sowing. In each case the land had the treatment usual in the region in preparing for wheat. The wheat was sown with a drill about Sept. 20, 1890. The winter was favorable for the crop. When visited at the last of April, as well as at harvest time, the effect of the barnyard manure in stimulating growth was very apparent; that of the superphosphate, less so. The wheat was carefully harvested and threshed from the shock, except at Flora, where Mr. Bowler was compelled to put it in stack and thresh Aug. 20. Mr. Helms estimates that his crop was damaged one-fifth or more by plant lice. The wheat at Nashville was measured; at the other places, weighed. It was all of good quality. The average results are given as follows: At Flora, 20 loads manure, 25.47 bushels wheat per acre; 400 pounds superphosphate,

17.83 bushels wheat; unfertilized, 19.71 bushels wheat. Odin, 20 loads manure, 25.47 bushels wheat; 400 pounds superphosphate, 19.85 bushels wheat; unfertilized, 19.64 bushels. Nashville, 20 loads manure, 28.00 bushels; 400 pounds superphosphate, 16.00 bushels; unfertilized, 10.00 bushels. Belleville, 20 loads manure, 40.70 bushels; 400 pounds superphosphate, 39.85 bushels; unfertilized, 36.65 bushels.

— While the International Marine Congress was in session in Washington in 1889, the question was raised as to the proper power of the running lights used by vessels of the merchant marine. No agreement could be reached, as the Congress was without accurate knowledge as to the intensity of the lights proposed. It has been decided that the side-lights of a vessel under way, which should be red on one side and green on the other, ought to be sufficiently powerful to be seen two miles, while the white top lights should be seen five miles. The Light-House Board was formally requested to ascertain the needed intensity of the proposed lights by actual experiment. The board therefore appointed a committee of five, consisting of two light-house inspectors, who are respectively a captain and a commander in the United States navy, two light-house engineers, who are respectively a major and a captain of the Corps of Engineers in the United States army, with a member of the Light-House Board as its chairman. The committee did its work by making actual tests at night, running a steamer at Gardiner's Bay, Long Island Sound, over a measured course, and sighting from various known distances, white, red, and green lights, the actual intensity of which had been determined by photometric measurement. This committee of specialists was attended by a staff of experts to put and keep the apparatus in thorough order. Two nights, each of a different character as to clearness, were spent in making these experiments, and two tabular statements showing actual and accurate results have been prepared. The result is that all the tests have been averaged, the personal equation of the observers has been eliminated, and a full report of the results attained has been made. From this it appears, stated in brief, that to be practically seen in fairly clear weather for five miles, a white light must have an intensity of thirty candle power, and that red and green lights to be seen two miles must each have a power of forty candles.

— A recent report by the United States consul at Martinique gives some details concerning the hurricane at that island on August 18. He states that early on that morning the sky presented a very leaden appearance, decidedly threatening, with occasional gusts of variable winds, mostly from the east-north east. The temperature was very oppressive during the entire day. The barometer varied only slightly, but was a little higher than usual until afternoon, when it commenced to fall, at first gradually and then very rapidly. The storm struck the east side of the island at about 6 P.M., rushing through the ravines with terrible force, and destroying every thing in its path. On the elevated plains the ruin was most complete. One very peculiar feature of the hurricane was the deafness experienced by every one during the storm, possibly the result of the reduced barometric pressure. During the cyclone the wind veered from east-north-east to south-south east, the latter being most destructive. During the storm there were incessant flashes of sheet lightning, unaccompanied by thunder, and immediately after the storm there were two distinct shocks of earthquake, at intervals of about five seconds. Early in September the consul visited Trinité, and all the way the destruction was most complete, the trees and vegetation looking as though there had been a forest fire, although without the charred appearance. The thermometer ranged from 90° to 100° F. during the storm. There was a deluge of rain, one account stating that over four inches fell in a few hours that evening. Nine-tenths of the buildings throughout the island were unroofed. The loss of life was small in St. Pierre, but large in the interior towns. The total loss of life, so far as reliable information can be obtained, was seven hundred, and the loss of property was enormous. All the fruit, the main reliance of the laboring class, was destroyed, and prices of provisions have advanced three hundred per cent. Every vessel was wrecked or badly damaged, fifty sail in all. A clipping from a Martinique newspaper states

that the barometer fell 27.95 inches at Fort de France. At St. Pierre the wind blew a hurricane from the north-east, from 7 to 8.15 P.M., when the rain suddenly stopped and it fell calm, the sky becoming clear. This marked the passage of the centre. At 8.30 the hurricane recommenced from the south-west, and blew with great fury until 9.30, the barometer rising and the wind shifting to the south-east. At 10.30 there were still strong squalls from the south-east, but the storm was practically over.

—Professor Frank H. Bigelow, at one time professor of mathematics and astronomy at Racine College, has been appointed a professor in the United States Weather Bureau.

—The Salisbury expedition to the Galapagos Islands, headed by Dr. Baur of Clark University, has returned to Worcester, Mass. It brings a large collection of scientific specimens.

—Dr. Alfred S. Bolles, superintendent of the Pennsylvania Bureau of Statistics at Harrisburg, and editor of the *Bankers' Magazine*, has been elected lecturer in mercantile law and banking in the University of Pennsylvania. Dr. John I. Reese has resigned the chair of medical jurisprudence and toxicology in the same university. In the Wharton School of Finance, Mr. L. K. Stein of Johns Hopkins University has been elected assistant, Dr. Sydney Sherwood, a Princeton graduate, becomes instructor in finance, and Dr. Frederick W. Moore of Yale, instructor in sociology.

—An instrument for optical comparison of transparent liquids, named a "liquoscope," has been recently devised by M. Sonden of Stockholm (*Nature*, Sept. 17). Two hollow prisms holding the liquids are separated by a partition at right angles to the refracting angle. The whole is placed in a vessel filled with glycerine, and which allows of vision in a horizontal direction through plane glass plates. The deflection of the light rays through the prisms is thus compensated. So long as the two liquids have the same optical action, one sees a distinct mark (say a black paper strip on a window) as a straight connected line; but its halves are relatively displaced if the liquids have different refractive powers. The amount of displacement gives a measure of the difference, the positive or negative nature of which also appears from the direction of displacement. The author recommends his apparatus for chemical purposes, especially comparison and testing of fats and oils, analysis of glycerine, etc.; and detection of margarine in butter, margarine greatly lowering the index of refraction.

—In a paper published in the current number of the *Journal of the Anthropological Society*, Mr. J. J. Lister refers to the great development of the arms and chests of the natives of Fakaofu (Bowditch Island, Union Group). According to *Nature*, he thinks it may be due to the fact that they are obliged to go about so much in canoes. Sir Joseph Lister, who took part in the discussion which followed the reading of this paper, remarked that he would not have expected the frequently repeated action of paddling to produce lengthening of the arms, although he could understand its resulting in increased size of chest. He pointed out that the natives of Tonga were also accustomed to use canoes, and hence it was not clear that the phenomenon could be traced to the cause assigned. Mr. Lister replied that, although the Tongans use canoes, canoe work is not so essential a part of their lives as it is in the case of the natives of Fakaofu. The natives of the island of Tongatabu have many avocations quite apart from the sea, for they live on an island twenty two miles long, and many villages are situated some distance from the water. The natives of Fakaofu, on the other hand, live crowded together on a small islet situated on a ring of reefs, and to meet almost every need of their lives they must do more or less paddling.

—Herr Fleitmann's experiments in soldering iron with nickel have yielded some important results with regard to the volatility and atomic penetration of the former metal, says *Iron*. The adhesion of the two metals was so intense that it became impossible to separate them by mechanical action, and chemical analysis proved a perfect assimilation, although the soldering had been effected at a temperature of from 500° to 600° below the fusing point. Other tests established the volatility of iron when heated to cherry redness. Two plates of iron and nickel, superposed, were submitted to the same degree of heat; the iron passed into

the nickel to a notable extent without soldering or adhesion of the surfaces resulting. On the whole surface of the sheet of nickel an alloy with the iron was formed, which, in the case of one-millimetre sheets, penetrated to five one-hundredths of their thickness, and contained on the average twenty-four per cent of that metal, the proportion being naturally stronger on the surface. An important fact is that the passage of the iron to the nickel is not reciprocal. While the combination disclosed itself on the surface of the nickel plate by the argentiferous lustre of an alloy of iron with fifty per cent of nickel, the iron plate remained intact, and preserved the sombre appearance which it had received from the scaling.

—In 1857 Wilhelm Struve, founder of the Pulkova Observatory, entered into negotiations with Prussia, Belgium, and England, with a view to the measurement of an arc of parallel of latitude stretching across the four countries. The Governments named consented, in 1863, to communicate the results of their measurements to Otto, son and successor of Wilhelm Struve, in order that he might co-ordinate them with the Russian triangulation. The measurement of the arc is not yet completed, but some particulars concerning the work have been published in a recent issue of the *Scottish Geographical Magazine*. The parallel chosen is that of 52° north latitude, and the angular extension of the arc is 59° 30'. The portion which lies within the bounds of Russia in Europe measures rather more than 1,682 miles in length, and gives the average length of a degree of longitude as about 42.68 miles. The geodetic measurements proved beyond a doubt that the length of a degree is not always the same, that, in fact, the parallel of 52° is not a circle, but is composed of elliptical arcs. Bases of 4 to 9 versts have been measured with such care as to reduce the limit of error to the hundredth part of a millimetre, yet the lengths of a degree of longitude in different parts of the parallel show differences ranging up to 410 feet. It is expected that the measurement will be continued across Siberia to the Pacific.

—*Nature* states that Herr Hufner has lately pointed out some of the biological bearings of the fact (observed in experiment along with Herr Albrecht) that long light-waves are much more strongly absorbed by water than short ones. If the lower marine animals had, like man, the liveliest light-perception with yellow rays, and a certain intensity of light were necessary to them, they must live at a less depth than if their visual organs were most strongly affected by short-waved rays. Thus, e.g., if they needed as much yellow light as that of the full moon, they could not live deeper than 177 metres (say, 590 feet). Yet they are found at all depths where food, oxygen, and a suitable temperature exist. On the other hand, the existence of plants having chlorophyll depends on light, and we might expect that the distribution of non-parasitic plants would be very limited, which is the case, no plant-organisms being found under 200 fathoms. Green plants assimilate best in yellow light; and supposing plants to assimilate in moonlight they would find their limit at the above depth (177 metres). But while yellow is here weakened to 0.0000016 of its brightness, indigo blue has still 0.007829 of its original strength, and the assimilation with blue rays will be 660 times as strong as with yellow. Different colored marine plants react differently according to the color of light, and they have accordingly different distribution in depth.

—The American Press Company of Baltimore announces a work entitled "The Builders of a Great Country." It will be a book of representative Americans. The proposed work will contain biographies and portraits of those who are recognized as the representative Americans of the age in church and state, politics and commerce, science and manufactures, literature and art, press and progress.

—An important work on the science and practice of medicine is announced by the Librairie G. Masson, Paris, under the editorship of Doctors Charcot, Bouchard, and Brissaud. "Le Traité de Médecine" will form six volumes, to be published within a maximum period of two years. The first volume, just ready, includes general infectious pathology, diseases of nutrition, diseases common to man and animals, and infectious diseases. The second volume will treat of fevers, cutaneous affections, diseases of the blood, and intoxication.

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Attention is called to the "Wants" column. All are invited to use it in soliciting information or seeking new positions. The name and address of applicants should be given in full, so that answers will go direct to them. The "Exchange" column is likewise open.

MOLECULAR MOTION IN HYDRODYNAMICS.

PROFESSOR JOSIAH P. COOKE'S "New Chemistry" has done much to dissipate the mystery which hung around the subject of molecules in my mind before this light was turned on. The physicist, says Professor Cooke, "may prefer to define molecules as those small particles of bodies which are not subdivided when the state of aggregation is changed by heat, and which move as units under the influence of this agent. To the chemist, on the other hand, the molecules determine those differences which distinguish substances. . . . Hence the chemist's definition of a molecule: 'The smallest particles of a substance in which the qualities inhere, or the smallest particles of a substance which can exist by themselves,' for both definitions are essentially the same" ("New Chemistry," pp. 99, 100). When we try to contemplate the magnitude of these small particles, the mind becomes bewildered by the immensity of the minuteness, in the same way that it is bewildered by the immensity of the expansion when it tries to penetrate the uttermost depths of the celestial spaces. But every child who sees the stars at night peers into these depths, and every one who hears the whistle or the rumble of a steam-engine is listening to the sound of work done by the movement of these minute particles.

In the long series of experiments which enabled Mr. William Crookes to develop the radiometer and Crookes's tubes, he became very familiar with these small bodies: not quite enough so to handle them as a boy does his marbles, or a sportsman his shot; but he furnished abundant proof, if any further proof was required, that the molecules are separate bodies of matter, each with the capacity for its own proper motion and of doing its own proper work. It is true that he did not prove that one molecule by itself could be made to do work like a rifle ball, because he failed to separate one from all others; but he leaves no doubt that when moving together, like shot from a smooth-bore gun, each molecule has its own proper motion and does its own proper work.

Applying this determination to the phenomena of hydro-mechanics, the explanation it affords is astonishing for its simplicity. This application is entirely legitimate; for while

Mr. Crookes's operations were on matter in gaseous form, it is now well known that all matter can be changed from one form to another, and the change of the substance which is the subject of hydromechanics from the solid form of ice to the liquid form of water and the gaseous form of vapor, are amongst the most obvious of all phenomena. Moreover, the very fact that water flows, demonstrates its separation into particles each capable of independent motion of its own. When grain passes along a conduit in an elevator, or when seed or shot are poured from one bag or vessel into another, there is a flow, each particle having a certain motion of its own; one moves faster and another slower, as it happens to be more or less subjected to the impelling force. If the particles did not change position in respect to each other, the phenomena would be sliding, not flowing. The essential difference between sliding and flowing is that in the one case, the particles, large or small, constituting the moving body, do not necessarily change position in respect to each other, while in the other this change of relative position of the particles really constitutes the movement of the mass. This is beautifully illustrated by pouring corn into a hopper or bin. When the bag or vessel containing the corn is tilted the grains on top begin to move toward the lower side, and presently begin to pour over, and are followed by the others, each one moving in obedience to its own gravitation and the pressure, if any, from grains above it, and its movement is determined by the resistance it encounters from other grains and the sides of the containing vessel. When the operation is completed no two grains probably occupy the same position in respect to each other, in the hopper or bin, that they did in the vessel from which they were poured. It is said that no two grains are precisely alike in every particular, and it is certainly probable that when a mass of grain flows from one vessel into another, no two of them have identically the same motion both in direction and velocity. The gravitational pull on each is the same, but the variation in pressure and resistance to which they are respectively subjected is practically infinite.

This phenomenon of flow is impossible except in a mass composed of particles free to move in respect to each other, and, therefore, the flowing of water is itself sufficient evidence that the water is composed of particles free to move in respect to each other, and that this motion of particles actually occurs whenever water or any other liquid flows. The decomposition of water has demonstrated that the particles composing it are molecules, as defined by Professor Cooke; that is to say, the particles constituting the water itself are the smallest in which the qualities of the substance inhere, and not aggregations of these smallest particles. When a molecule of water is subdivided, as it may be, there is no water left; the water is destroyed, and the matter assumes the form of oxygen and hydrogen, which in certain combination form the molecule of water. (Decomposition, *ex vi termini*, imports a separation of particles; thus when ice is decomposed into water, the particles separate, and there is a further separation of particles when water is decomposed into vapor; therefore when further decomposition destroys the substance itself, it is obvious that the substance must have been subdivided by precedent decomposition into the smallest particles in which its qualities inhere.) It is obvious, therefore, that a vessel full of water is filled with an aggregation of molecules, in the same sense precisely that a bushel measure full of corn is filled with an aggregation of grains.

It is not necessary for us to determine whether the molecules of water are held apart and kept separate by intermo-

molecular vibration, as supposed in the kinetic theory; nor whether the atoms constituting the molecules "are in a state of vibration or rotation motion, in short, comparable to the bodies of the solar system," as suggested by Mr. William Crookes in a recent article in *The Forum*. These interesting qualities, supposed to be possessed by molecules, or by atoms constituting the molecules, but not by particles composed of an aggregation of molecules, are in no wise inconsistent with the obvious fact that molecules possess some of the qualities of other particles of matter: they are subject to the force of gravitation; that is, they have weight, and weight is simply the evidence and measure of the earth's gravitational attraction. Considering, then, that a body of water consists of molecules in the same sense that a body of corn consists of grains, it is manifest that the molecules below the surface must sustain the pressure caused by the weight of the superincumbent molecules above, and that this pressure must increase with the depth, because the quantity of superincumbent molecules increases in the same ratio. An increase of pressure not essentially different occurs whenever particles of any kind are superimposed, as in a grain elevator or a brick wall. It is therefore obvious that nothing but the weight of the superincumbent molecules is necessary to account for hydrostatic pressure; and the molecules being free to move in respect to each other, all the phenomena of hydrostatic pressure must follow, under the general law of the conservation of energy, and its resultant, that motion is always in the direction of least resistance.

But it is not necessary to consider in detail the phenomena of hydrostatic pressure, for they are the secondary and not the immediate results of molecular motion, that is, of the motion of the molecules constituting the water. This motion is the change of position of molecules which constitute the mass or body of water, in respect to each other, and is contradistinguished from molar motion, which is the change of position of the mass in respect to other masses, or of part of a mass in respect to other parts of the same mass. Molecular motion may occur from convection without molar motion, as when heat below the boiling point is applied to the bottom of a vessel containing water; the heated molecules rise to the surface, and the colder molecules at the surface sink towards the bottom, the body or mass of the water remaining stationary. So there may be molar motion without molecular motion, as when a vessel full of water is moved from one place to another without agitating the water. But in the phenomena of flowing or pouring, both of these motions necessarily occur: there is a change of the position of the molecules if the subject be water, or of the particles if the subject be grain, seed, shot, etc., in respect to each other, and there is also a change of position of the mass in respect to other things, and of parts of the mass in respect to other parts of the same mass. When corn is poured from one vessel into another, we can see the grains change position in respect to each other, and if this did not occur we would know at once that the grain was sliding, not pouring or flowing. We cannot see, even with the most powerful glasses, the molecules of water: one grain of corn equals in bulk many billions of them; but the results of the phenomena of flowing and pouring water leave no more doubt that the molecules do change position in respect to each other, than if we saw the motion of each one separately. Indeed, if the lower part of the water in a vessel be colored with sediment or other matter, and the water be poured into another vessel, we have visible evidence of the change of position of the molecules in respect to each other by the trans-

fusion of the colored particles throughout the mass in the second vessel.

Flowing and pouring are terms used to express different phases of the same phenomenon. What actually occurs in every case of flowing or pouring is the transference of a fluid or semi-fluid—that is, of a mass composed of small particles—from one place or vessel to another by the action of gravitation or some other force acting directly on the mass itself, and not merely on the vessel containing the mass. We know by observation when this phenomenon occurs in a quasi-fluid, consisting of grains or particles large enough to

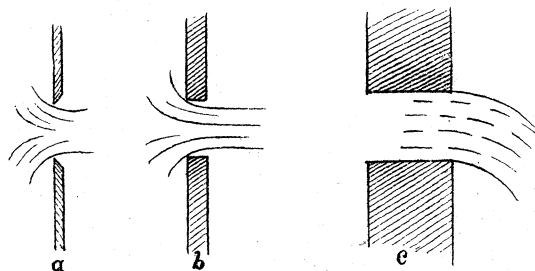


FIG. 20.

be observed, that each grain or particle has a motion of its own, and is subject to the mechanical laws applicable to all moving bodies; and assuming the same to be true in respect to the invisible molecules constituting a fluid proper, we find an explanation of the phenomena of hydraulics, absolutely simple and perfectly satisfactory.

For example we will take the diminution in the diameter of a jet projected from an orifice in a plain surface; and to illustrate the phenomenon we will borrow the following explanation and diagrams from the last edition of the "Encyclopedia Britannica": "When a jet issues from an aperture

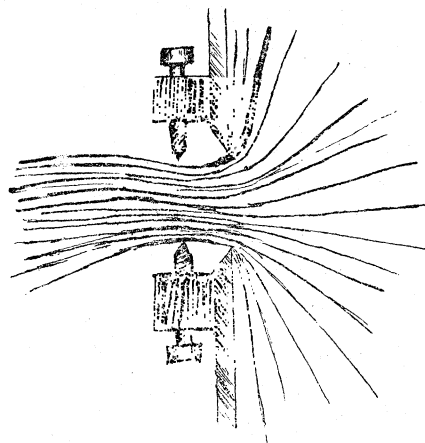


FIG. 21.

in a vessel, it may either spring clear from the inner edge of the orifice as at *a* or *b* [Fig. 20], or it may adhere to the sides of the orifice as at *c*. The former condition will be found if the orifice is beveled outwards as at *a*, so as to be sharp-edged, and it will occur generally for a prismatic aperture like *b*, provided the thickness of the vessel round the aperture is less than the diameter of the jet. But if the thickness is greater the condition shown at *c* will occur. When the discharge takes place as at *a* or *b*, the section of the jet is smaller than the section of the orifice. This is due to the formation of the jet from filaments converging to the orifice in all directions inside the vessel. The inertia of the fila-

ments opposes sudden change of direction of motion at the edge of the orifice, and the convergence continues for a distance of about half the diameter of the orifice beyond it. . . . When the orifice is a sharp-edged orifice in a plain surface, . . . the section of the jet is very nearly five eighths of the orifice. . . . Hence the actual discharge when contraction occurs is . . . 0.62." "The coefficient of contraction is directly determined by measuring the dimensions of the jet. For this purpose fixed screws of fine pitch [Fig. 21] are convenient. These are set to touch the jet, and the distance between them can be measured at leisure." Without stopping to inquire what reason there may be, either in theory or from observation, for the assumption that the molecules, or particles of water, form themselves into *filaments*, and that the jet is formed from these filaments, it is obvious that the assumption is not necessary to account for the phenomenon, and that the diminution of the jet is the necessary result of well-known mechanical laws operating on each molecule separately.

Each molecule put in motion by the outflow of the jet moves from its position in the vessel towards the orifice: the motion is constantly accelerated until it reaches the orifice, and its velocity is determined by the pressure to which the molecule is subjected and the resistance it encounters. The molecules on the same horizontal plane as the orifice, and

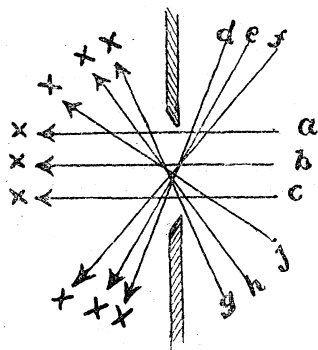


FIG. 21 (modified).

on lines which lead through it, move on these lines directly outwards through the orifice; but the molecules above and below and on each side of the orifice move towards it at an angle to the direction of the outflow, and a part of the kinetic energy of the molecules moving directing in the line of outflow is necessarily consumed in changing the direction of the molecules from above, below, and from the sides, which are moving at an angle to this direction. In other words, it is the ordinary simple problem of moving bodies coming into contact at an angle to their lines of motion, and the direction of motion and kinetic energy are the resultant of the forces operating at the impact.

This can be illustrated by reproducing Fig. 21, omitting the set-screws, and substituting for the filaments a few molecules with lines showing the direction of their motion. The molecules *a*, *b*, and *c* move on the lines *ax*, *bx*, and *cx*, while the molecules *d*, *e*, *f*, move on the lines *dx*, *ex*, and *fx*, and the molecules *g*, *h*, *i*, move on the lines *gx*, *hx*, and *ix*, and so with all the others. The amount of kinetic energy consumed in changing the direction of the molecules moving to the orifice at an angle to the direction of the outflow, determines the diminution of area of the jet as compared with the area of the orifice, and determines also the co-efficient of discharge.

When the point of maximum contraction is reached, the

molecules, under another well-known law of mechanics, rebound from each other, and at about the distance from the orifice to the point of maximum contraction, the area of the jet is enlarged so that it equals the area of the orifice, and farther on becomes much larger. The amount of contraction of the jet is necessarily variable, depending as it does on the direction of the molecules when they reach the orifice. If the vessel is narrow, or if, in Fig. 21, an obstruction be placed in the vessel in front of the orifice, so as to diminish the relative number of molecules which can move on the lines *ax*, *bx*, and *cx*, as compared with those which move at an angle to the line of outflow, the area of the jet and co-efficient of discharge will be measurably diminished.

If the orifice is bell-mouthed, or otherwise so constructed that the kinetic energy required to change the direction of all the molecules is exerted before any of them reach the orifice, then there is no contraction of the jet, and the co-efficient of discharge rises from about 0.62 to about 0.96 under the same conditions in other respects.

But it is in determining the depth at which the maximum velocity is found in a flowing stream that the molecular motion becomes of the greatest importance. We again have recourse to the "Encyclopedia Britannica" for a description of the phenomenon, and the existing theories in respect to it: "In the next place, all the best observations show that the maximum velocity is to be found, not at the free surface of the stream, but some distance below it. In the experiments on the Mississippi the vertical velocity curve in calm weather was found to agree fairly well with a parabola, the greatest velocity being at three-tenths of the depth of the stream from the surface. With a wind blowing down-stream the surface velocity is increased and the axis of the parabola approaches the surface. On the contrary, with the wind blowing up-stream the surface velocity is diminished, and the axis of the parabola is lowered, sometimes to half the depth of the stream. The American observers drew from their observations the conclusion that there was an energetic retarding action at the surface of a stream like that due to the bottom and sides. If there were such a retarding action, the position of the filament of maximum velocity below the surface would be explained. It is not difficult to understand that a wind acting on surface ripples should accelerate or retard the surface motion of the stream, and the Mississippi results may be accepted, so far as showing that the surface velocity of a stream is variable when the mean velocity is constant. Hence, observations on surface velocity by floats and otherwise should only be made in very calm weather. But it is very difficult to suppose that in still air there is a resistance at the free surface of the stream at all analogous to that at the sides and bottom. Further, in very careful experiments, Boileau found the maximum velocity, though raised a little above its velocity for calm weather, still at considerable distance below the surface velocity, even when the wind was blowing down-stream with a velocity greater than that of the stream, and when the action of the air must have been an accelerating and not a retarding action. Professor James Thomson has given a much more probable explanation of the diminution of the velocity at and near the free surface. He points out that portions of water, with a diminished velocity by retardation from the sides or bottom, are thrown off in eddying masses and mingle with the rest of the stream. These eddying masses modify the velocity in all parts of the stream, but have their greatest influence at the free surface. Reaching the free surface, they spread out and remain there, mingling with the water at that level,

and diminishing the velocity which would otherwise be found there."

Then follow the determinations of Boileau and of Bazin, from which it may be inferred "that the ratio at which the maximum velocity is found to the whole depth ranges from zero to 0.2, except in some artificial channels, where it reached 0.35. The Mississippi experiments give different results, and Bazin inclines to believe that the method of experimenting was untrustworthy. The ratio is greatest in artificial channels with smooth bottoms, and least in natural streams with rough bottoms.

It is difficult to understand what force could cause the portions of water retarded by the sides or bottom to spread themselves with constant uniformity over the unimpeded current flowing below the surface in mid-stream, and especially how the portions retarded by the bottom could rise up through or pass around the more rapid portions above them. But the phenomenon becomes very simple if we suppose that each molecule of the water has its own proper motion, governed by well-known mechanical laws. The impetus to the motion is determined by the pressure, and the actual motion is necessarily the resultant of the difference between the pressure and the resistance. If there were no resistance to the flow of the stream, there would be constant acceleration of motion from top to bottom, just as there is in jets from the side of a vessel, the flow from each being determined by the pressure above it. But in a flowing stream there is great resistance from the sides and bottom, the resistance from the bottom necessarily increasing with the pressure, and this resistance which the molecules receive from the bottom is transmitted, just as pressure is from above, to the molecules adjacent to them. At the depth where the impetus to motion by the pressure from above comes into equipoise with the resistance to motion from below, there ought to be, as there is in fact, the greatest velocity of flow. The resistance from the bottom remains practically constant at any given place in the stream. Wind blowing up-stream increases the pressure by holding back the surface molecules; hence this increase of pressure, the resistance remaining constant, causes the level of maximum velocity to descend. On the other hand, when the wind blows down-stream there is a diminution of pressure, because the surface molecules are pushed forwards in the direction of their movement; hence this diminution of pressure, the resistance still remaining constant, causes the level of maximum velocity to ascend. When the flow is through a round pipe entirely filled with water, and under such pressure that the influence of gravity on the stream itself may be disregarded, it is obvious that the maximum velocity is through the centre of the pipe; the pressure is uniform in all parts of a cross-section of the pipe, and the resistance from friction against the pipe is likewise uniform in all directions from the centre.

It is not necessary to seek further evidence of molecular motion in other phenomena of hydraulics. The evidence is manifest in all the phenomena that I have examined; and the motion is not only consistent with the facts, but the hypothesis of its existence clears up many things which without it are obscure. The explanation which it furnishes of the phenomena of wave motion is especially interesting, but the subject is too large for consideration in this paper.

It seems to me, therefore, that, without further illustration, we may assume as determined that, in all flowing, the particles or molecules constituting the body in which the phenomenon occurs, whether visible or invisible, have each

its own proper motion, determined by the forces and resistances to which it is subjected, and that the molar motion is made up of the aggregation of these molecular or particle-motions,—and in this consists the specific difference between flowing and sliding.

This determination is evidently of theoretical importance in hydromechanics and in pneumatics, for the law must apply to the flowing of gas as well as to the flow of liquids, and it may lead to other determinations of great practical value in one or both of these sciences. But since Mr. Crookes has put the molecules of residual gas, in the bulb of the radiometer and in his tubes, to doing mechanical work, the basis has been laid for the development of the science of molecular mechanics, and it is in this new field that this determination has its greatest importance.

The eyes of scientists are being directed to what we might call the small end of nature, and we are discovering that microbes, bacilli, bacteria, etc., are of more importance to mankind than the cedars of Lebanon, or the beasts which roamed beneath them, or the birds which sought shelter in their branches. So in this new science of molecular mechanics, the way to which has been opened up to us by Mr. Crookes's researches, we have the promise of additions to scientific knowledge more important even than the magnificent results which followed the application of mechanical laws to the movements of the celestial bodies.

DANIEL S. TROY.

LETTERS TO THE EDITOR.

Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.

On request in advance, one hundred copies of the number containing his communication will be furnished free to any correspondent.

The editor will be glad to publish any queries consonant with the character of the journal.

Rain-Making.

In the issue of *Science* of Aug. 28 there appears a communication from Professor H. A. Hazen attacking the artificial rain theory, to some points in which I ask the privilege of making reply.

Professor Hazen commences by saying that "ever since the time of Plutarch the idea has been prevalent that great battles are invariably followed by rain." Now, I would ask where Professor Hazen gets his authority for this broad and sweeping statement? In what writings, following those of Plutarch, does he find any reference to the matter up to the time of Benvenuto Cellini, who is said to have written that a discharge of artillery affected meteorological conditions? Plutarch lived in the first century of the Christian era, Cellini lived in the sixteenth century. Here is a great gap of about fifteen hundred years, and if there is any evidence that the idea prevailed, during that time, that battles caused rain, I challenge my critic to produce it.

A great many writers besides Professor Hazen have brought forward the statement of Plutarch relative to rains following battles as an argument against the concussion theory of rain-production, and some appear to think the argument quite unanswerable. It is, however, very easily disposed of, for the notion referred to by Plutarch was an entirely different matter from that which, so far as we know, did not come into notice until fifteen hundred years later. It was wholly different, in that it did not relate to rains immediately following battles. The only place in which Plutarch mentions the subject is in his life of Marius, in speaking of the defeat of the Ambrones by the Romans. The rains which he says followed that battle did not occur until the winter following. And in mentioning the subject in a general way in connection with this one specific instance, the whole tenor of what he says conveys the idea that the rains he referred to did not occur until a considerable time after the battles, nor until the bodies of the slain had putrified. To give what he says other meaning is to make his attempted explanation of the cause of the rains wholly

inapplicable. How absurd, then, to claim that the ancients had the same notion in regard to rains following battles as that which prevails at the present day. We might well question, indeed, whether there was any such idea prevailing among the ancients as that to which Plutarch alludes, as a single and unsupported statement by one writer alone is not very conclusive evidence; but admitting that he may have spoken advisedly on the subject, it is plain that it was not a "common thought" with that of the moderns, and all reasoning against the concussion theory based on it must fall to the ground.

The second point in Professor Hazen's article to which I wish to refer is the wholly unwarranted assumption that all, or nearly all, the battles of our late war which I have not shown in "War and the Weather" to have been followed by rain, were not so followed. On a par with this is the violence he does to history in assuming that the 2,200 battles which he says were fought during that war were, on an average, as severe as the 153 mentioned in my book. The greater part of the 2,042 which he says I do not mention could have been nothing more than skirmishes. The most remarkable thing about Professor Hazen's article is that although he has read my book he pays no attention to any of the explanations or arguments I make. I explain the difficulty, from want of records, of getting reliable information in regard to the weather following the land battles that were fought, and he coolly proceeds to count all those not proved to have been followed by rain as belonging to the other side. I give a reason why we should not expect skirmishes to produce rain, and he counts them all in as if one such, not followed by rain, furnished as good evidence against the theory as a great battle followed by heavy rain furnishes for it. By this cheap method of figuring he makes out that only seven per cent of the battles were followed by rain. What weight has such an argument against the fact that all the great historic battles of the war, so far as reliable information can be obtained, were followed by heavy rains?

Professor Hazen argues that the influence of explosions could not extend twenty-four hours, for the reason that the current subjected to it "is borne along at the rate of 20, and, in the higher strata, at 30, 40, 50, and more, miles per hour, so that the specific influence from them will be carried at least 500 miles away in twenty-four hours." Now the learned professor cannot be sure of his ground here unless his knowledge of all atmospheric movements and of processes in the formation of storm centres is infallible. It is generally understood that our Weather Bureau claims such infallibility, though Professor Hazen in another part of his article seems to disclaim it, and though some of the unscientifically are inclined to believe that the whole orthodox theory of rain-formation will yet have to be remodelled.

Professor Hazen does not think my explanation of the point under consideration worthy of notice, as he does not refer to it. This explanation is as follows. The storm centre may remain stationary over the place where the firing takes place until the storm is fully established, because it is caused by the mingling of two currents of air flowing in nearly opposite directions. At the commencement, the new action set up is confined to the upper stratum of the lower current and the lower stratum of the upper current. These, mingling together, set up a rotary motion, but as a whole, the air partaking of this motion moves neither very far east nor very far west, being acted on by opposing forces, one tending to carry it eastward and the other westward. When, however, large enough volumes of air become involved in the motion to produce rain, the storm will move eastward along with the warm current. As this is not orthodox philosophy as held by the scientists of the Weather Bureau, Professor Hazen will have none of it. But perhaps he will remember cases in which storm centres have lingered long in one place, and, if so, this fact alone furnishes a sufficient argument in refutation of his own.

There is only one other point in Professor Hazen's article that I wish to notice, and that is this: he says, "One thing seems very evident, that absolutely no rain can be obtained out of a dry atmosphere." This is an old argument the extreme tenuity of which I have often shown. Professor Hazen well knows how I have met it by showing that there are probably at all times sufficient quantities of aqueous vapor flowing above us in air currents

to make rain. He cannot refute my argument on this point, nor I believe, show that there is anything unreasonable in it, therefore he very wisely ignores it. My argument is based on the absolutely certain fact that as much water must come to us from the ocean as runs into the ocean from our rivers, and on the further fact, demonstrated by Professor M. F. Maury, that most of the vapor that forms our rains comes to us from the Pacific Ocean. Coming from the Pacific, it necessarily comes in air currents which flow above the mountains and high above the arid regions of the West. Meteorologists will come nearer a solution of the problem of rain-production when they recognize the fact that it is not the moisture in the lower air east of those mountains and arid districts that gives us our rains, but that it is the rains formed mainly by the condensation of the vapor from the Pacific that cause the moisture.

EDWARD POWERS.

Delavan, Wis., Sept. 26.

BOOK-REVIEWS.

Schliemann's Excavations. By DR. C. SCHUCHHARDT. Trans. from the German by Eugénie Sellers. New York, Macmillan. \$4.

THE object of this work is to give a succinct account of Dr. Schliemann's discoveries, sufficient for most students of the subject, and presenting the net results in a single volume. The reports heretofore made of the excavations, chiefly by Dr. Schliemann himself, are contained in several different books published at intervals, none of which contains a complete account of the whole work, so that a good summary was much needed; and such a summary Dr. Schuchhardt, with the approval of Schliemann himself, has here given us. He has also taken account of the discoveries that have been made by others, especially those of the Greek Archaeological Society, while Drs. Schliemann and Dörpfeld have given in an appendix reports of their excavations at Hissarlik last year; so that we get a complete account of all that has been done. Mr. Walter Leaf contributes an introduction in which he discusses certain points of interest, expressing in some cases somewhat different views from those of Dr. Schuchhardt. Dr. Schliemann's work was so emphatically the result of his own personality, and his life was in itself so interesting, that Dr. Schuchhardt very properly begins his volume with a biographical sketch. Schliemann was the son of a clergyman, and received excellent schooling in early boyhood; but, owing to misfortunes in the family, he was obliged to leave school and go to work to earn his living. For several years his life was hard; but at last a firm in Amsterdam detected his commercial abilities, and from that time his advancement was rapid. The foundation of his large fortune seems to have been laid in Russia during the Crimean war; but it was not until several years later that he was able to retire from business with a fortune sufficient to carry on the archaeological researches which had been the dream of his life. The first sod was turned at Hissarlik in 1870, and, as the excavations were continued with some interruptions until the great explorer's death last year, they covered a period of twenty years.

Of the importance of the work thus done there can be no doubt; it was, as Mr. Leaf remarks, nothing less than the creation of prehistoric Greek archaeology. Before Schliemann's excavations began, most scholars doubted the story of the Trojan war, maintaining that it was a poetic fiction and that the personages represented in the "Iliad" and "Odyssey" were mythical, and there was great uncertainty as to the site of Troy itself. Dr. Schliemann has now uncovered the site of Troy just where Greek tradition uniformly placed it; and, as the ruins show that the city was destroyed by fire, its reduction by siege is highly probable. Thus far only the citadel has been excavated; but the massiveness of its walls prove that it must have been the nucleus of a large and powerful city, though the utensils and ornaments that have been found indicate a lower stage of civilization than that of the prehistoric cities on the European side of the sea.

It is at these last-named cities, indeed, and especially at Mycenæ and Tiryns, that the most important discoveries have been made. Tiryns, which stood nearest the sea, was first excavated, and here Schliemann first had the assistance of Dr. W. Dörpfeld,

who had previously been engaged on the German excavations at Olympia. The remains uncovered at Tiryns consist of a citadel and palaces almost identical in plan with those of Troy; and these features are repeated with some variations at Mycenæ. It was at this latter place, however, which Homer has celebrated as the capital of Agamemnon's empire, that the greatest variety of remains were found, and Dr. Schuchhardt has devoted nearly half of this book to a description of them. There are at Mycenæ two different kinds of burial places, the bee-hive tombs outside the citadel (so called from the form of the principal vaulted chamber), and the shaft graves within the citadel, which are simple pits sunk in the ground and covered by a slab. The bee-hive tombs, which belong to the later ages of the Mycenaean civilization, have long since been rifled of their contents; but the shaft graves were found to contain remnants of corpses, together with a great variety of utensils, ornaments, and weapons which reveal a high order of workmanship and artistic skill. The shield of Achilles and other works of art spoken of in the "Iliad" have been regarded as extravagant creations of the poet's fancy; but here at Mycenæ we find objects of precisely that character — goblets, diadems, and even shoulder-straps of gold, artistic pottery of various kinds, and sword blades and daggers inlaid with figures of men and animals made of gold, silver, and other rich material. Similar objects have been found in various parts of the Grecian mainland, and on the islands of the Ægean, so that the civilization they betoken must have been widespread; but where its centre was and what particular race were its representatives are questions still unsettled. The period of its prevalence is still more uncertain, but is vaguely assigned to the interval between 1500 and 1000 B.C.

These questions, and others of equal importance, to which Schliemann's discoveries have given rise, have been discussed by Dr. Schuchhardt in his concluding chapter, and by Mr. Leaf in his introduction. We want to trace the connection of the Mycenaean civilization with the nations of the east and with the later developments among the Greeks themselves, and also to find out the relation between that civilization and the one presented in the poems of Homer. The resemblances between the life revealed to us in the Mycenaean remains and that depicted in the "Iliad" and "Odyssey" are numerous and obvious; but there are also discrepancies which our present information does not allow us to account for, and which seem to show that the poems date from a later age than that of the Mycenaean prime. The most important of these differences is in the mode of disposing of the bodies of the dead, which at Mycenæ were buried, whereas in the "Iliad" and "Odyssey" they are burnt on the funeral pyre. The figures portrayed on some of the ornaments and weapons at Mycenæ also show a mode of dress quite different from that described by Homer; and it is evident that we must have further information before the difficulties thus presented can be cleared up. Meanwhile, we cannot withhold our tribute of admiration and respect for the man who has taught us so much about the life and civilization of those early ages.

Stones for Building and Decoration. By GEORGE P. MERRILL. New York, Wiley. 8°. \$5.

THE author of this work is curator of geology in the United States National Museum, and he has succeeded in treating the subject in a way that will make the volume of especial interest to architects and engineers without lessening its value to the student, or, in fact, to any person interested, whether from an economic or a purely scientific standpoint. Though the subject is presented mainly from an American point of view, the volume includes descriptions of all stones of importance found in the American market, from whatever source they may come.

The first chapter gives a brief but very interesting history of stone-working in the United States. The succeeding chapters of Part I. are devoted to the geographical distribution and the chemical and physical properties of such stones as are used for general constructive and decorative purposes.

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Mr. Merrill has made excellent use of the opportunities afforded him by his position in the National Museum to gain a thorough knowledge of his subject, and has given us a most exhaustive and comprehensive treatise on an interesting topic.

AMONG THE PUBLISHERS.

A NEW feature has just been introduced in the *New England Magazine*. It is, "In a Corner at Dodsley's," a gossip about writers and books, by Walter Blackburn Harte.

— Macmillan & Co. have been appointed special agents in the United States for the books published in London by George Bell & Sons, including the well-known collection of standard literature issued under the name of "Bohn's Libraries."

— In *St. Nicholas* for October is a short letter from Meredith Nugent explaining where grasshoppers and crickets tried to hide their ears until Sir John Lubbock rummaged them out for us. It would be a knowing boy indeed who would not be surprised to find a grasshopper's ear on his fore-leg.

— Among the contents of the *Engineering Magazine* for October are the following: "Progress in Aerial Navigation," by O. Chanute; "One View of the Keely Motor," by T. C. Smith; "Railroad Building on the Texas Frontier," by G. W. Rafter; "Marble Quarrying in the United States," by E. R. Morse; "The Conditions Causing a Tornado," by Professor H. A. Hazen; and "The Future of Our Wagon Roads," by W. Claypoole.

— The October number of *The Alienist and Neurologist* contains a paper on the subject of "Traumatic Neuroses and Spinal Concussion," another on "The Insanity of Torquato Tasso," an illustrated study of "Criminals and Their Cranial Development," "The Weight of the Brains of the Feeble-Minded," and "A Study of the Heredity of Inebriety." The respective writers are Guiseppe Seppilli, W. W. Ireland, G. Frank Lydston, A. W. Wilmarth, and T. L. Wright. Besides there are the usual selections, editorials, hospital notes, reviews, etc.

— With the issue of the second number of the *Journal of Comparative Neurology*, the editor, C. L. Herrick, indicates the sphere which it will attempt to occupy. The *Journal* offers to investigators an avenue for immediate publication with full illustration, there being no restrictions as to size or frequency of the fascicules. A feature is the list of current neurological literature, which it is hoped may be made complete and accurate, and in connection with this are given synopses of the more important papers. Critical estimates or reviews of such papers, however, will usually be offered only in connection with special *résumés* or digests of given topics. While especially devoted to original investigation, each volume will contain semi-popular, historical, and controversial matter which may serve to adapt the results of the technical work to the general reader. While it is inevitable that much of the space will, for the present, be occupied with anatomical and morphological matter, it is hoped to devote an increasing amount of attention to physiological problems and to the accumulation of data which may serve, in however indirect a way, as materials for a comparative psychology. All observers are invited to contribute facts having any scientific bearing upon the nervous or psychical activities of animals. It is the intention soon to inaugurate a series of articles to constitute, when completed, a laboratory guide to the study of the nervous system, to which the attention of

teachers is especially invited, with the request that criticism and suggestion be freely offered. Address all communications to C. L. Herrick, University of Cincinnati, Cincinnati, Ohio.

— Dr. Lansdell is engaged on a volume that will embody the results of his last journey in the East. He travelled over 50,000 miles, visiting Little Thibet and the less-known districts of Chinese Central Asia.

— Messrs. Swan Sonnenschein & Co. will issue the following books during the autumn season: "The Colours of Animals," by Professor Beddard, with colored and other plates and woodcuts; "Text-book of Embryology: Man and Mammals," by Dr. Oscar Hertwig, professor of comparative anatomy in the University of Berlin, translated and edited from the third German edition (with the assistance of the author) by Dr. E. L. Mark, professor of anatomy in Harvard University, with 389 illustrations and 2 colored plates; "Text-book of Embryology: Invertebrates," by Drs. Korschelt and Heider of the University of Berlin, translated and edited by Dr. E. L. Mark, with several hundred illustrations; "Text-book of Animal Palæontology," by Dr. Thomas Roberts, designed as a supplement to Claus and Sedwick's "Text-book of Zoology," illustrated; "Text-book of Geology," adapted from the work of Dr. Emanuel Kayser, professor in the University of Marburg, by Philip Lake of St. John's College, Cambridge, with illustrations; "Text-book of Zoology," by Dr. Claus of the University of Vienna, and Adam Sedgwick, F.R.S., Vol. II. "Mol-

lusca to Man," third edition; "The Geographical Distribution of Disease in England and Wales," by Alfred Haviland, M.D., with several colored maps; "Introductory Science Text-books" — Additions: Introductions to the study of "Physiography," by H. M. Hutchinson; "Zoology," by B. Lindsay; "Amphioxus," by Dr. B. Hatschek of the University of Vienna, and James Tuckey; "Geology," by Dr. Edward Aveling; "Physiological Psychology," by Dr. Th. Ziehen of the University of Jena, adapted by Dr. Otto Beyer, with 21 figures. "Young Collector Series" — Additions: "The Telescope," by J. W. Williams; "British Birds," by the Rev. H. C. Macpherson; "Flowering Plants," by James Britten; "Grasses," by W. Hutchinson; "Fishes," by the Rev. H. C. Macpherson; "Mammalia," by the Rev. H. C. Macpherson.

— The *New England Magazine* for October has an article on "The Public Libraries of Massachusetts," by Henry S. Nourse.

— P. Blakiston, Son, & Co., Philadelphia, have brought out a second American edition of Richter's "Chemistry of the Carbon Compounds, or Organic Chemistry." This new edition is based on the sixth German edition. As is well known, Richter is the professor of chemistry at the University of Breslau. The translation is made by Edgar F. Smith, professor of chemistry at the University of Pennsylvania. Professor Smith is widely known as a translator and as the author of a number of chemical works. Richter's "Organic Chemistry" is one of the most comprehensive books on the subject at present available in English. Not only is the theory

Publications received at Editor's Office,
Sept. 30-Oct. 6.

- GILMAN, N. P., and JACKSON, E. P. Conduct as a Fine Art. Boston and New York, Houghton, Mifflin & Co. 230 p. 8°. \$1.50.
GORE, J. H. Geodesy (Riverside Science Series). Boston and New York, Houghton, Mifflin & Co. 218 p. 12°. \$1.25.
IRVING, W. Rip Van Winkle. (Riverside Literature Series). Boston, Houghton, Mifflin & Co. 99 p. 12°. 15 cents.
MACDONALD, M. Harmony of Ancient History, and Chronology of the Egyptians and Jews. Philadelphia, Lippincott. 301 p. 8°. \$2.
SADTLER, S. P. A Hand-Book of Industrial Organic Chemistry. Philadelphia, Lippincott. 518 p. 4°. \$5.

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— In the *Review of Reviews* each month the pages of small print at the end of the periodical contain classified lists of all the new books that have lately appeared, with bits of running comment on them; lists of the contents of all the principal periodicals of America, England, France, Germany, Italy, Belgium, and the Scandi-

navian countries; and a complete index, which under one alphabet lists the important articles that have appeared in the previous month in every important periodical published in the English language.

— The opening article of *The Century* for October is the closing one of Mr. Kennan's series, and is entitled "My Last Days in Siberia." He describes his experiences among the Kachinski Tatars and the political exiles of Minusinsk, and with the "plague-guard" or quarantine, and narrates the journey by way of Tobolsk and Tiumen to St. Petersburg. The promised article by Hiram S. Maxim, the inventor, on "Aerial Navigation" appears in this number, and considers particularly the question of the power required for aviation. Mr. Maxim discusses the philosophy of the subject and relates the progress of his experiments at Kent, England, which are illustrated with drawings of the machine employed. He also adds a forecast of the possible future uses of the new mode of locomotion.

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